PROPULSION DIRECTORATE

Monthly Accomplishment Report
October 2003

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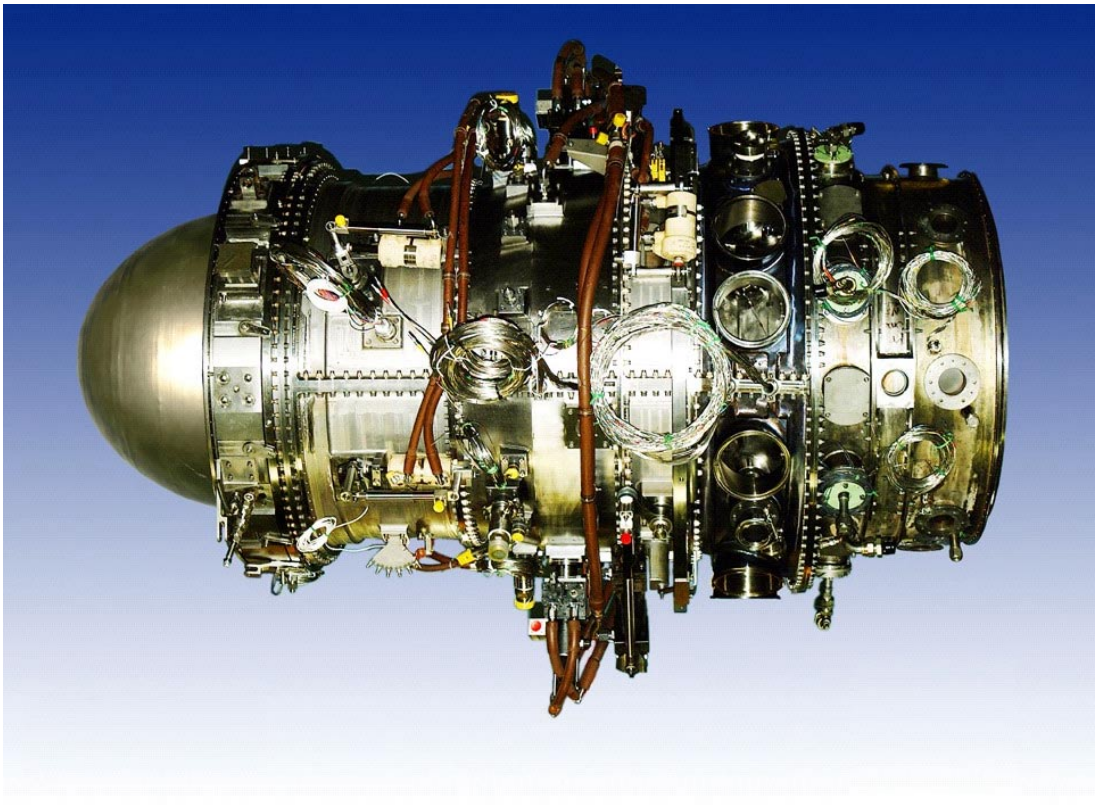
JET ENGINE CORE TEST SETS NEW WORLD RECORD: In support of the DoD Integrated High Performance Turbine Engine Technology (IHPTET) Program and the F136 (F-35 aircraft) Advanced Technology Demonstrator program, a joint government, General Electric (GE), and Allison Advanced Development Company (AADC) team successfully completed 48 hours of advanced jet engine core testing at the Rolls-Royce facility in Indianapolis, Indiana. The GE/AADC Advanced Turbine Engine Gas Generator (ATEGG), identified as XTC76/3B, successfully demonstrated the highest ever steady state rotor inlet temperature (T4.1), measured at 50°F higher than the IHPTET Phase II baseline. The core showcased a high-pressure ratio core-driven fan stage, advanced compressor aerodynamics, Ceramic Matrix Composite (CMC) and advanced Lamilloy® combustor materials, a turbine rotor consisting of a rainbow of AADC single crystal Castcool Lamilloy® and GE "ICE" turbine blades, key features of the variable cycle engine architecture, hybrid ceramic bearings, and several other technologies required by the F136 engine. The posttest review revealed that the maximum demo point matched very well with pretest predictions and the hardware remained in good condition. The XTC76/3B will now be refurbished and assembled into the full Joint Technology Demonstrator Engine (JTDE), XTE76/1, which is projected to achieve a 60% increase in thrust-to-weight over the IHPTET baseline. (Mr. A. Cerminaro, AFRL/PRTP, (937) 255-7622)



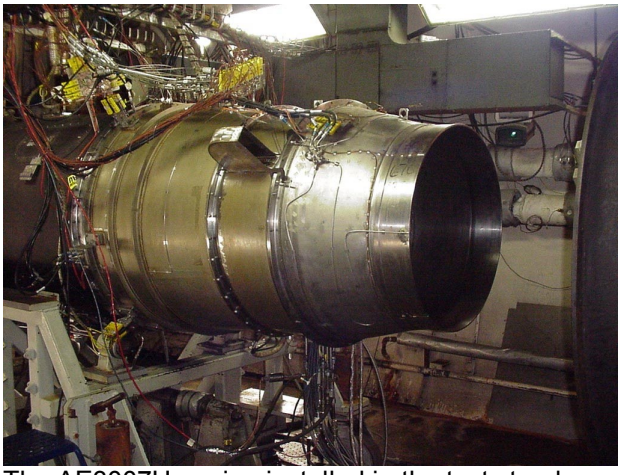
The XTC76/3B demonstrator

IMPROVED BATTERIES SUCCESSFULLY TRANSITIONED TO THE B-2: Lithium-ion batteries developed under the DoD/NASA Lithium-Ion Battery Initiative, an initiative in which the Propulsion Directorate is a major participant, have been successfully transitioned to the B-2. The B-2 recently completed 81.5 hours of successful flight testing using these batteries. Notably,

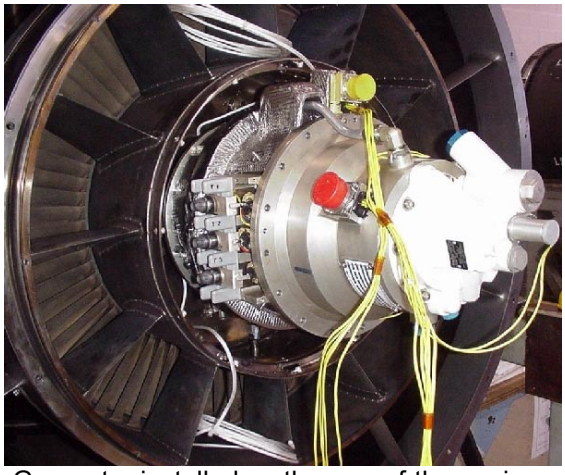
the B-2 is the first operational Air Force aircraft to install rechargeable lithium-ion batteries in place of nickel-cadmium batteries. The new lithium-ion batteries provide the B-2 with four times the battery power over the existing batteries and also enable the B-2 to operate at temperatures as low as -40°C (-40°F). In addition, with the new batteries the B-2 is now upgradeable to Link 16 communication capability. (Dr. J. Erbacher, AFRL/PRPS, (937) 255-2372)

The Propulsion Directorate transitioned lithium-ion battery technology to the B-2

ENGINE TESTS COMPLETED FOR GLOBAL HAWK ENGINE GENERATOR: Rolls-Royce, in coordination with Allison Advanced Development Company (AADC) and Innovative Power Solutions (IPS), successfully completed a series of tests of a Global Hawk-rated AE3007H engine with an electric generator directly coupled to its low-pressure fan spool. The generator extracts power from the fan spool as opposed to the standard gearbox-mounted generator which is driven from the high-pressure spool. This allows greater power output at high altitude with reduced engine thrust loss and improved stall margin. Projected power capacity at altitude is three times greater than the baseline gearbox-driven generator, and nearly double the peak limit allowed for gearbox generator power extraction. These tests were the culmination of a Small Business Innovation Research (SBIR) topic to develop an in-flight engine start capability for the Global Hawk aircraft, with an added goal of increasing available power for aircraft loads. The generator and its control unit were designed and built by SBIR contractor IPS, and the Propulsion Directorate contracted AADC to design the AE3007H modifications to allow generator



The AE3007H engine installed in the test stand



Generator installed on the rear of the engine fan spool

installation and engine spool drive. The test series included 60 hours of endurance test, engine acceleration and generator load transient response, vibration scan, and generator thermal soakback evaluation with a 90kW generator overload. (E. Durkin, AFRL/PRPG, (937) 255-6206)

OHIO GOVERNOR ANNOUNCES NEW AEROSPACE INITIATIVE: On 27 October 2003, Ohio Governor Bob Taft announced a $10M "Third Frontier" award creating the Ohio Center for Advanced Propulsion and Power in Columbus, Ohio. The efforts under this initiative directly support the Air Force's propulsion and power goals. The Propulsion Directorate will work with NASA Glenn Research Center, the state of Ohio, Ohio State University, the Air Force Institute of Technology, the University of Dayton and other educational institutions, as well as industrial partners, to ensure development of the propulsion and power technologies the nation needs in the future. This collaborative effort, aimed at developing next generation propulsion systems, is a very positive development for Wright-Patterson AFB and AFRL. The center hopes to position the state to capture a significant share of the estimated 80,000 jobs expected to be created from new propulsion technologies over the next 20 years. This could include increased investments in PR's high payoff technologies such as the Versatile Affordable Advanced Turbine Engines and More Electric Aircraft initiatives that support PR's goals and objectives. (Col M. Heil, AFRL/PR, (937) 255-2520)

FIRST MICRO GRAVITY SPRAY COOLING FLIGHT EXPERIMENTS: In October 2003, a micro gravity thermophysics research team from the Propulsion Directorate flew a spray cooling experiment for the first time aboard NASA's KC-135A micro gravity test bed. The purpose of the experiment was to investigate the effects of micro- and high-g environments on spray cooling systems. Spray cooling is a potential solution to the thermal management of high heat flux sources aboard air and space platforms. This spray cooling experiment represents the first time there has been a concentrated research effort in the US to specifically address the potential of spray cooling for space applications. This experiment was part of an ongoing collaboration with the NASA Glenn Research Center (GRC) micro gravity research group. Four test flights were conducted at NASA GRC with approximately 40 test parabolas per flight. These tests allowed AFRL and NASA researchers to conduct initial experiments to observe fluid dynamic and thermophysical phenomena of sprays in micro- and high-g environments. (Dr. K. Yerkes, AFRL/PRPS, (937) 255-5721)

Mr. Travis Michalak (left) and 2Lt Ryan Claycamp (right) monitor the spray cooling experiment during a parabola

SOLID ROCKET MOTOR BEHAVIOR PREDICTION TESTS BEGIN: The Propulsion Directorate recently fired six

10-inch diameter special subscale solid rocket motors to support computer modeling efforts. Data from these firings will be used to test the ability of computer models to predict the effect of solid rocket motor propellant deformation and fracture, caused by the effect of internal combustion flow and rocket case structural deflection, on propellant grain shape. Successful validation of the computer model will allow designers to use the model to reduce the weight of solid rocket motors without risking catastrophic motor failure, thus increasing payload and reliability. The internal geometry of these motors was designed to experience varying levels of deformation during propellant ignition, and the model was used to predict which motors would fracture and which would perform successfully. Transient x-ray radiography was used to collect deformation data. (Dr. G. Ruderman, AFRL/PRSB, (661) 275-5332)

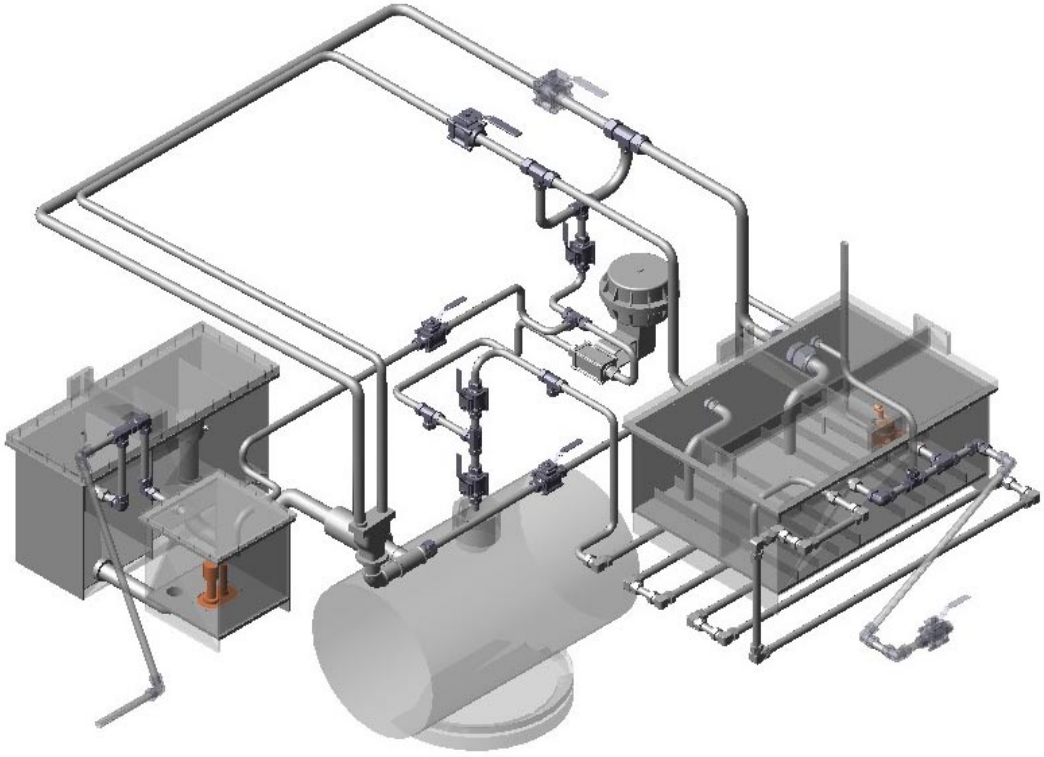
Subscale solid rocket motors


A test motor firing

FACILITY UPGRADE AIDS DEVELOPMENT OF COST-SAVING FUEL ADDITIVE: In response to high demand and strong support from operational units, the Propulsion Directorate recently completed a significant upgrade of its low temperature jet fuel testing capabilities. Testing of fuels and additives is now underway in a newly upgraded full-scale test system that utilizes actual U-2 flight hardware. The use of U-2 tanks, sumps, filters, and plumbing in the test system allows extremely realistic and reliable testing of various fuel and additive formulations without risking the safety of aircrew or aircraft. This upgrade will enable further development of low temperature fuels and fuel additives in support of the U-2. Conventional jet fuels turn into a frozen slush when exposed to the extremely low temperatures of high altitude flight. In the

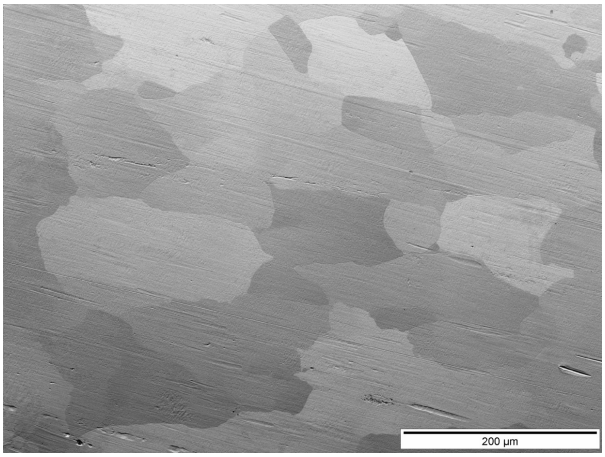

PR is working to develop a more cost effective fuel for the U-2

execution of its high altitude reconnaissance mission, the U-2 is exposed to this harsh, low temperature environment and consequently requires an expensive, specialized low temperature fuel called JPTS. PR is developing a low cost additive that can be added to standard aviation fuel (i.e., JP-8) to allow it to operate at low temperatures. It is estimated that switching U-2 operation from JPTS to JP-8 would save the U-2 community at least $8 million per year. (Ms. C. Obringer, AFRL/PRTG, (937) 255-6390)



Computer image of the full-scale test system configured to realistically simulate operation of the U-2 fuel system

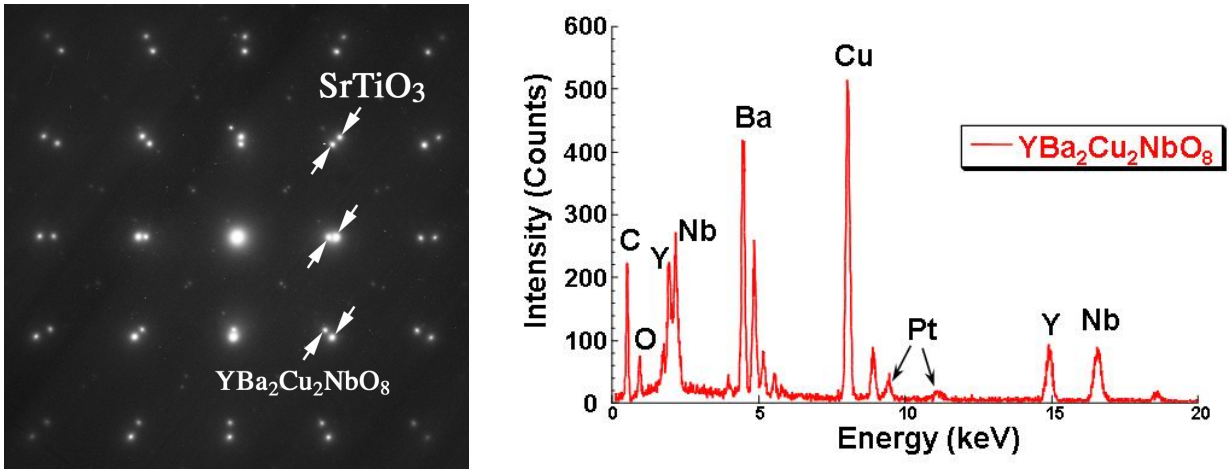
PROCESS FOR HIGHLY TEXTURED COPPER DEVELOPED: Mr. Nick Yust, a co-op in the Propulsion Directorate's Superconductivity Group and a graduate student at Wright State University, has developed a process for forming highly textured copper foil as a substrate for high temperature superconducting (HTS) coated conductors. High current densities are routinely obtained in coated YBCO conductors using textured nickel and nickel alloy. Copper may be used as an alternate substrate that is both non-magnetic, for lower ac losses, and highly conductive, for thermal and electrical quench protection. Highly textured metallic copper substrate tapes were produced using the rolling-assisted biaxially textured substrate, or RABiTS process. This technique incorporates cold



Scanning electron microscope (SEM) image of copper microstructure

rolling and subsequent recrystallization resulting in excellent in-plane as well as out-of-plane alignment. X-ray diffraction was performed indicating good in- and out-of-plane texture in the copper. Future success of textured metallic substrates based on copper will hinge on identifying a successful alloy for mechanical strengthening along with the appropriate buffers. Work is continuing in this area. (Dr. P. Barnes, AFRL/PRPG, (937) 255-4410)

NEW PHASE MATERIAL REPORTED: Dr. Srinivas Sathiraju, a National Research Council Senior Associate working in the Propulsion Directorate's Superconductivity Group, reported the formation of a new phase material, $YBa_2NbCu_2O_8$ (YBCNO), at the American Ceramic Society's Electrochemical Society Meeting in October 2003. YBCNO is being developed as a potential new buffer layer for high temperature superconducting (HTS) coated conductors. HTS coated conductors can enable compact high power generators for airborne applications. YBCNO films were deposited using pulsed laser deposition, and supporting characterizations included x-ray diffraction patterns, x-ray photoelectron spectroscopy, raman microscopy, and transmission electron microscopy (TEM) analysis. TEM analysis confirmed the phase formation. The Superconductivity Group is actively investigating the functional oxide materials as possible buffer layers on textured metallic substrates for coated conductor applications. (Dr. P. Barnes, AFRL/PRPG, (937) 255-4410)



Transmission electron microscopy (TEM) confirmed the formation of $YBa_2NbCu_2O_8$

DR. DEJOSEPH HONORED FOR BASIC RESEARCH LEADERSHIP: The Propulsion Directorate's Dr. Charles DeJoseph, Jr. was recently selected to receive the Meritorious Civilian Service Award in recognition of his distinguished performance from January 1994 through October 2002. Dr. DeJoseph demonstrated outstanding leadership, management skill, and technical expertise over an extended period as he led one of the premier basic research groups in the Air Force. He heads the "Collisional Plasma and Discharge Physics" task which has been conferred AFOSR Star Team status. He made significant contributions to research on Diamond-Like Carbon (DLC) capacitor materials; a technology vital to numerous applications such as Directed Energy Weapons (DEW). He also explored other exotic but affordable higher payoff dielectric materials, and his work on carbon and aluminum-nitride dielectrics has shown great promise. Furthermore, he contributed to basic research efforts addressing the ignition and burning of fuels in a scramjet combustor. Dr. DeJoseph's stellar performance has been the driving force

behind a myriad of successes in plasma physics research and technology transition. (Mr. J. Weimer, AFRL/PRPE, (937) 255-6236)


Dr. Charles DeJoseph, Jr. was selected to receive the Exemplary Civilian Service Award

MAJOR KEE WINS BEST STUDENT PAPER AT DIRECTED ENERGY SYMPOSIUM: The Sixth Annual Directed Energy Symposium, sponsored by the Directed Energy Professional Society, was held from 20-24 October 2003 in Albuquerque, New Mexico. Major Patrick Kee's presentation, "Optical Signatures for Process Control of High Temperature Superconductor (HTS) Production," was named the Best Student Paper at the symposium. Major Kee is a graduate student at the Air Force Institute of Technology, and he performs research on YBCO, a high temperature superconductor, in collaboration with the Propulsion Directorate's Superconductivity Group. This symposium brought together researchers, managers, and policy makers from a variety of universities and government agencies for discussions of current programs, technology efforts, and the future of directed energy technologies. The symposium provided a forum for the exchange of technical information in fields related to the development, testing, and fielding of High Energy Laser (HEL) and High Power Microwave (HPM) systems. HTS generators can provide the compact, lightweight, high power generators to power these systems. (Dr. P. Barnes, AFRL/PRPG, (937) 255-4410)


Major Patrick Kee (left) received the Best Student Paper Award at the Sixth Annual Directed Energy Symposium

INTERN HONORED FOR RESEARCH EXCELLENCE: Mr. Ronnie Allan was recently named the Pennsylvania State University College of Engineering Intern of the Year for his work with the Propulsion Directorate. Mr. Allan was honored for his work on a project titled "Modeling of Particle

Transport through an Arbitrary Gas Flow," the goal of which was to gain a better understanding of two-phase flow in high altitude rocket plumes. Mr. Allan's results are being directly incorporated into PR's AFOSR-funded Direct Simulation Monte Carlo modeling research, and work on this project is continuing at Penn State as Mr. Allan has made it his senior thesis project. PR's Drs. Dean Wadsworth and Andrew Ketsdever served as mentors to Mr. Allan on this project. (J. Levine, AFRL/PRSA, (661) 275-6179)

Mr. Ronnie Allan (center) was named the Pennsylvania State University College of Engineering Intern of the Year for his work with the Propulsion Directorate